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U. S. A R M Y

TRANSPORTATION RESEARCH COMMAND

FORT EUSTIS, VIRGINIA

CRASH INJURY BULLETIN

**MODIFICATIONS TO THE PASSENGER SEAT-BELT
TIEDOWN ATTACHMENTS IN THE**

U.S. ARMY HU-1 SERIES BELL IROQUOIS HELICOPTER

Contract DA-44-177-TC-802

TCREC Technical Report 62-45

prepared by :

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FOREWORD


This report was prepared by Aviation Crash Injury Research, a division of Flight Safety Foundation, Inc., under the terms of Contract DA 44-177-TC-802. Views expressed in the report have not been reviewed or approved by the Department of the Army; however, conclusions and recommendations contained therein are concurred in by this Command.

Analysis of several HU-1 helicopter accidents has disclosed a definite weakness in the occupant tiedown system. This deficiency has contributed, either directly or indirectly, to the injury of personnel involved in these accidents.

This report proposes both an interim fix and a permanent solution to the problem of troop seat safety belt anchorage failures in the HU-1 series aircraft. A complete list of equipment required, cost of retrofit, manhours required for installation, and detailed installation drawings are included herein. Also, step by step retrofit instructions are included for use of maintenance personnel.

This report has been forwarded by cover letter to the Chief of Transportation, U. S. Army, requesting that immediate action be taken to implement the recommendations of the Contractor in this instance. Recommendations are applicable to all existing and future production HU-1 series helicopters.

FOR THE COMMANDER:

for 
EARL A. WIRTH
CWO-4 USA
Adjutant

APPROVED BY:


WILLIAM J. NOLAN
USATRECOM Project Engineer

Task 9R95-20-001-01
Contract DA 44-177-TC-802
May 1962

**MODIFICATIONS TO THE PASSENGER SEAT
BELT TIEDOWN ATTACHMENTS IN THE
U. S. ARMY HU-1 SERIES BELL IROQUOIS HELICOPTER**

Crash Injury Bulletin
AvCIR 62-1

Prepared by
Aviation Crash Injury Research
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for
U. S. ARMY TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

CRASH INJURY BULLETIN

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Figure 1. Side View of an HU-1A in Flight.

SUMMARY

Analysis of several HU-1 helicopter accidents has disclosed a definite weakness in the occupant tiedown system.

A quick "off-the-shelf" interim fix is presented to make the existing system four times more effective.

A permanent fix is suggested that would ensure the strength of the tiedown to be equal to the seat-belt strength.

CONCLUSION

On the basis of accident experience and a detailed analysis of the passenger seat-belt attachment system in the HU-1 helicopter, it is concluded that the system does not provide the required flexibility or strength at the point of attachment to the basic structure of the aircraft.

RECOMMENDATIONS

Based upon the foregoing conclusion, it is recommended that:

1. A bulletin be issued requiring that the passenger seat-belt installation in the HU-1 helicopter be modified with certain "off-the-shelf" parts, as described in the interim-solution section of this report.
2. Consideration be given to the development and issue of a modification kit of the type described in this report as a permanent solution to the problem.
3. The permanent solution, or an equivalent design, be incorporated by the manufacturer in all future production models.

DEVELOPMENT OF THE PROBLEM

A review of several HU-1 helicopter accidents* reveals that failure of the passenger seat-belt tiedown occurs at the casting where the cable clevis is attached.

Figure 2 illustrates the tiedown installation as presently installed in HU-1 helicopters.

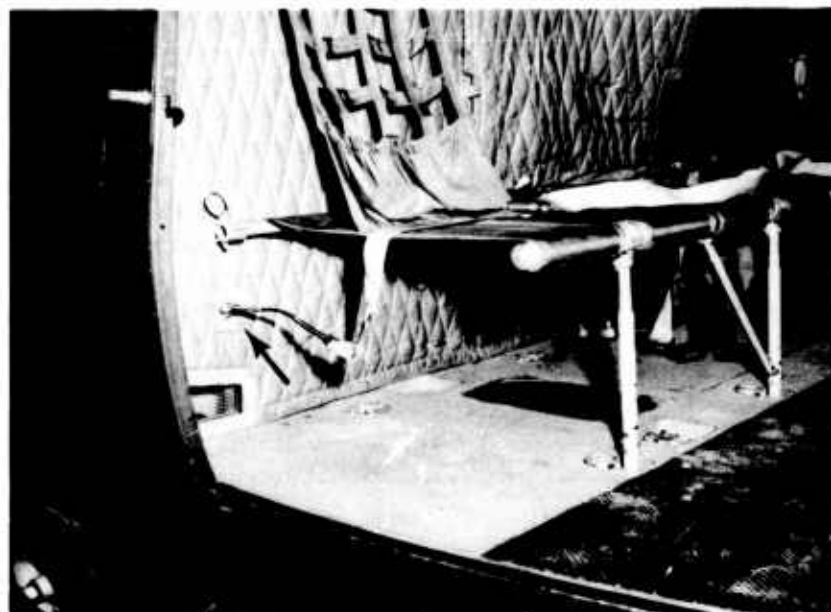


Figure 2. Typical Seat-Belt Tiedown Installation in the HU-1 Helicopter.

Figure 3 illustrates a typical failure of the aluminum seat-belt tiedown casting. The rigidity of the system is obvious.

Note that lateral movement is not possible at the point where the fork-end is attached to the casting. Excessive bending stresses at the attachment flange of the seat-belt tiedown bracket can be produced by side loads transmitted through the seat belt.

* Typical of these are the 10 August 1961, Fort Carson, Colorado, accident (TREC Technical Report No. 62-10) and the 4 May 1961, Korea, HU-1A accident.



Figure 3. Typical Failure of the Seat-Belt Tiedown Casting.

This is verified by the following quote from a crash telefax message (reference Appendix I):

- " 4. During maintenance on HU-1A crew chief unintentionally applied lateral (side) force on a passenger safety belt causing the cable attaching bracket to break identical to bracket in above accident. A Check was made on two other safety belts and it was found that the brackets would fail when a side load less than 200 NR was applied. "

Only 1 degree of freedom (vertical) is available with this attachment system. Spot checks of several HU-1A helicopters revealed that the fork-end cable terminals were tightened on the casting so tight that the vertical freedom was eliminated, resulting in a rigid connection from the cable to the casting.

The present cable attachment provides a moment arm of approximately 4 inches when side loads are applied as shown in Figure 4. With this moment arm, only 800 inch-pounds (4 inches x 200 pounds) of direct side moment are required to break the attachment casting.

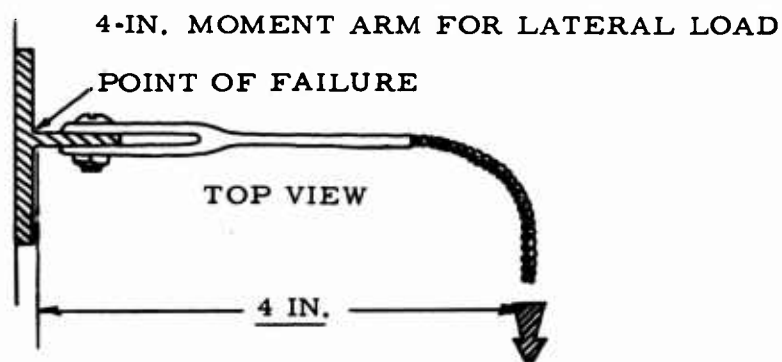


Figure 4. Present Tiedown Configuration.

INTERIM SOLUTION

To provide maximum protection against forces in all directions as experienced in aircraft accidents, a seat-belt attachment system should always be self-aligning or omnidirectional.

The 4-inch moment arm could be reduced to 1 inch if two "off-the-shelf" cable shackles were installed between the end of the cable terminal and the tiedown bracket, as illustrated in Figures 4 and 5.

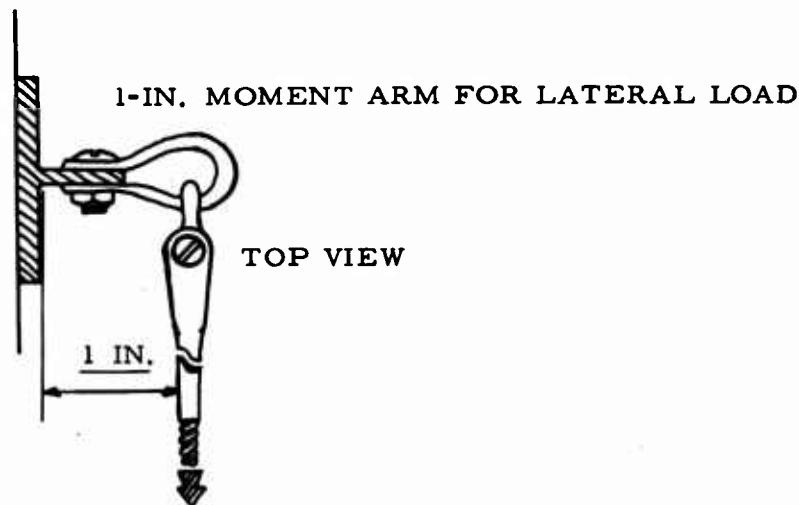


Figure 5. Suggested Interim Configuration.

This simple arrangement would increase side load capacity by 400 percent. It would also make the attachment omnidirectional and could be quickly installed in the field with available "off-the-shelf" components.

The parts required to modify the two ends of each passenger seat-belt installation are as follows:

<u>Quantity</u>	<u>Name</u>	<u>Part No.</u>
4	Cable Shackle	AN 115-80
2	Nut	AN 364-524A
2	Clevis Bolt	AN 25-14

The procedure for installing the parts set forth above is as follows:

1. Separate the fork-end cable terminal from the tiedown bracket by removing the nut and bolt.
2. Interlock two cable shackles.
3. Using the same nut and bolt that held the fork-end cable terminal to the bracket, assemble one of the interlocked cable shackles to the bracket.
4. Disassemble the nut and bolt securing the ring coupling that is attached to the eye-end cable terminal and the seat-belt fitting, thus freeing the cable.
5. Reverse the cable, then insert the eye-end cable terminal in the remaining interlocked cable shackle and secure with the AN 25-14 bolt and AN 364-524A nut.
6. Insert the bolt that secured the ring coupling in the fork-end cable terminal and secure with its nut.
7. Attach the seat-belt snap hook fitting to the fork-end cable terminal at the bolt.

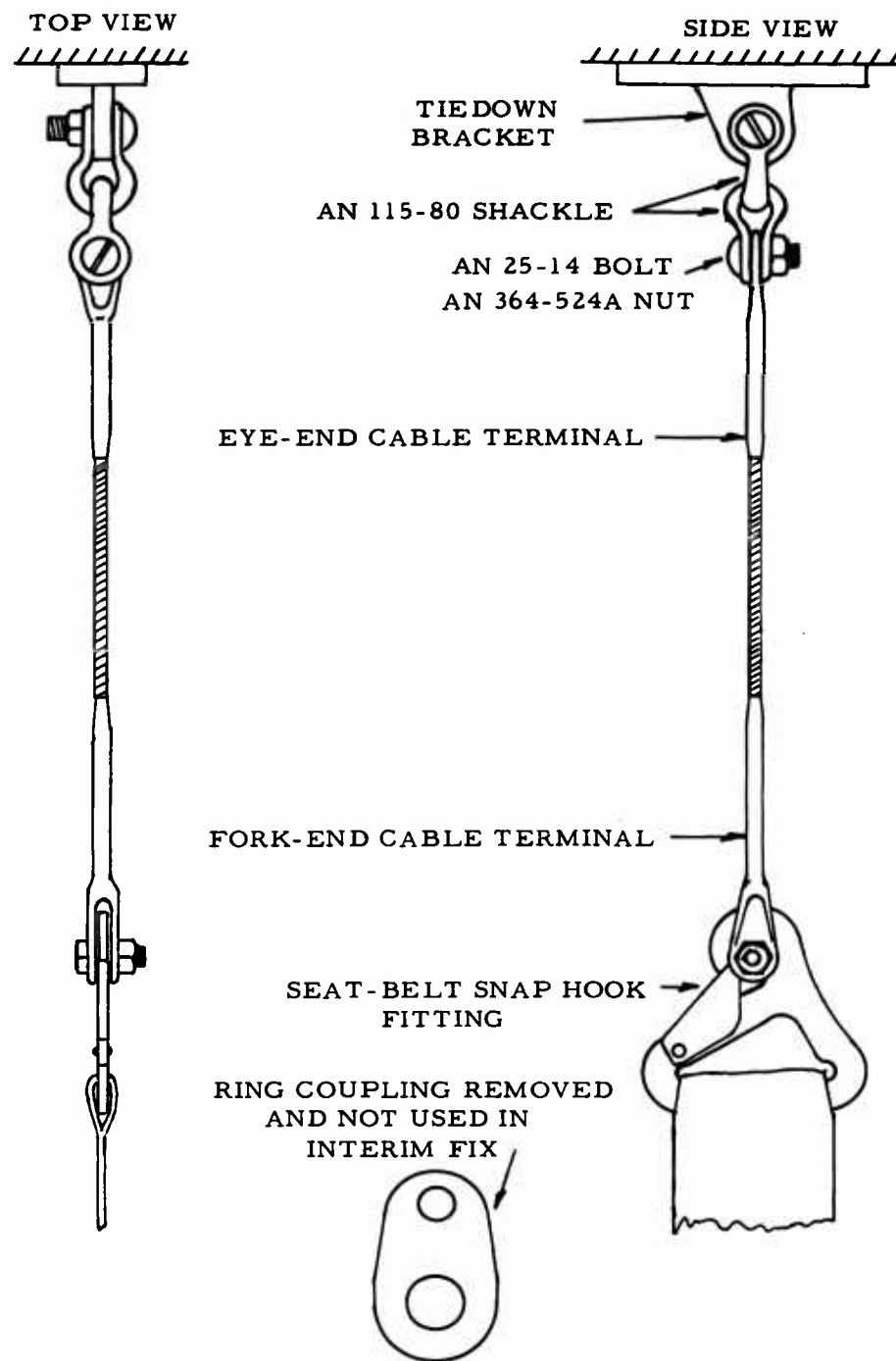


Figure 6. Interim Solution.

SUGGESTED PERMANENT SOLUTION

The foregoing temporary solution would result in an omnidirectional load capability as well as a 400 percent increase in side load strength; however, the increased strength is still considerably less than that needed to resist normal crash loads. A permanent solution should be provided which would eliminate the brittle casting bracket and would increase the strength of the attachment to that of the seat belt. The present troop belts are constructed in accordance with Bell Aircraft Corporation drawings 204-070-759 and 204-070-032; these belts are stressed for 4,500 and 5,000 pounds, respectively. The attachment fittings detailed in this report can be stressed to 5,000 pounds (25G) static load, but their excellent elongation properties would permit higher dynamic load peaks for short time spans. The reasons for selecting materials with high elongation properties are discussed more fully in Appendix III.

The permanent solution would consist of replacing the existing HU-1 rear passenger tiedown brackets with 5 new brackets and 16 stainless steel straps. The new brackets and straps are shown in Figures 7, 8, and 9. The installation time for the retrofit of one aircraft is estimated not to exceed 1 hour. No weight penalty would be involved, since the retrofit assembly will be no heavier than the existing tiedown assembly. The cost of retrofitting one aircraft will not exceed \$25.00 total cost. (See Appendix II.) The parts required to retrofit the HU-1 rear-passenger seat-belt tiedown assembly are as follows:

<u>Quantity</u>	<u>Name</u>	<u>Part No.</u>
16	Steel Strap	HU-1-1
4	"Channel" Fitting	HU-1-2
1	Tee Fitting	HU-1-3
4	Bolt	AN 5-15
1	Bolt	AN 5-10
8	Clevis Bolt	AN 25-10
5	Nut	AN 365-524
8	Nut	AN 364-524
40	Flat Washer	AN 960-516

The HU-1-1 strap is made from annealed 301 stainless steel sheet because of its excellent energy-absorbing properties. It is superior to normalized 4130 steel for this application because of its lower yield strength, which allows the strap to begin "stretching" at 10G's and to continue stretching to its total elongation of 1.5 inches and ultimate load of 25G's. In comparison, the 4130 steel would not begin to yield until 22G's was reached (see Appendix IV), and then it would "stretch" only to .55 inch. However, due to its lower cost, the 4130 steel is specified as a second choice. The strap is "necked down" through the center portion to ensure an equal stress distribution which will result in the maximum elongation during impact loads.

The HU-1-2 outboard fittings are specified as 301 stainless steel sheet because of its excellent energy-absorbing properties as well as its easy formability. A good second choice would be 2014-T4 aluminum channel as described by AND 10137-1309.

The HU-1-3 center fitting is specified as a 2014-T4 "Tee" extrusion, but because of its limited availability, 1020 mild steel would be an acceptable substitute. Both of these "Tees" are made to the correct size, and no machining other than chamfering the ends is necessary.

This retrofit will increase the strength of the brackets and straps to the extent that they will be compatible with the 5,000-pound belts as specified earlier in this section.

MATERIAL: - 301 STAINLESS STEEL ANNEALED (1ST CHOICE)
2014-T4 EXTRUSION (AND 10137-1309) (2ND CHOICE)
MATERIAL THICKNESS: - 0.125

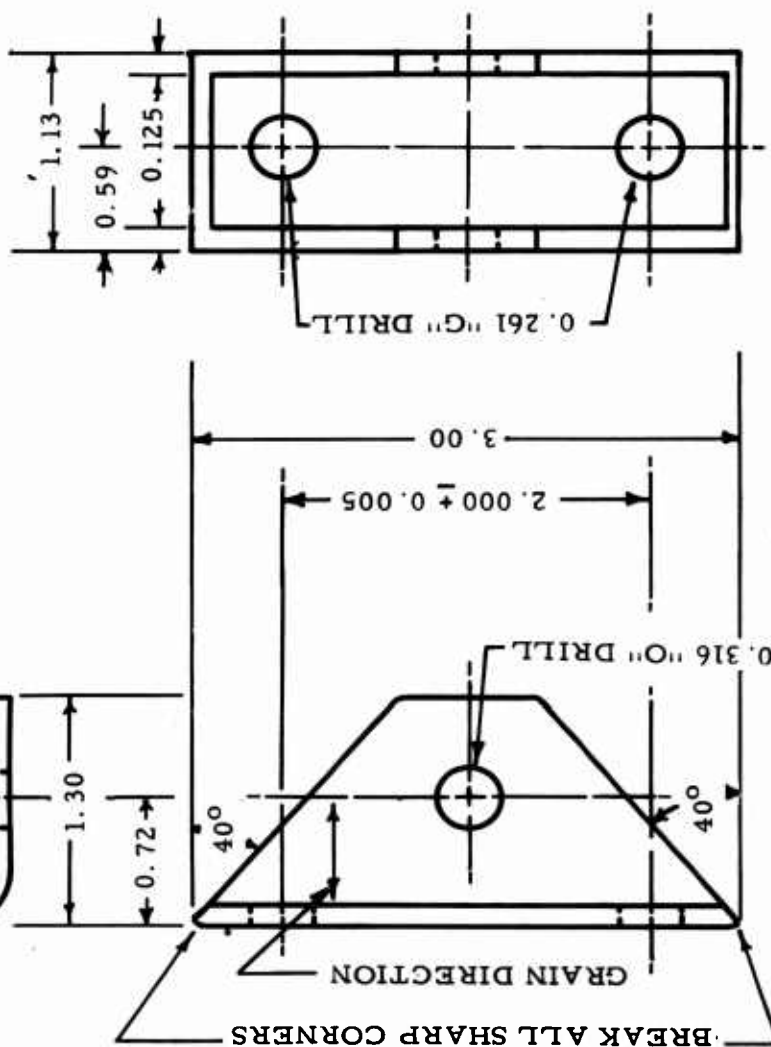


Figure 7. "Channel" Fitting HU-1-2.

SCALE: FULL
 ALL ANGLES $\pm 2^\circ$
 ALL DIMENSIONS ± 0.03 UNLESS OTHERWISE NOTED

MATERIAL:
 1ST CHOICE - 2014-T4 OR 2024-T4 ALUM. ALLOY TEE
 (REYNOLDS METAL CO. SECTION # 4712)
 2ND CHOICE - 1020 STEEL TEE - DUCOMMUN METALS AND
 SUPPLY COMPANY PHOENIX, ARIZONA

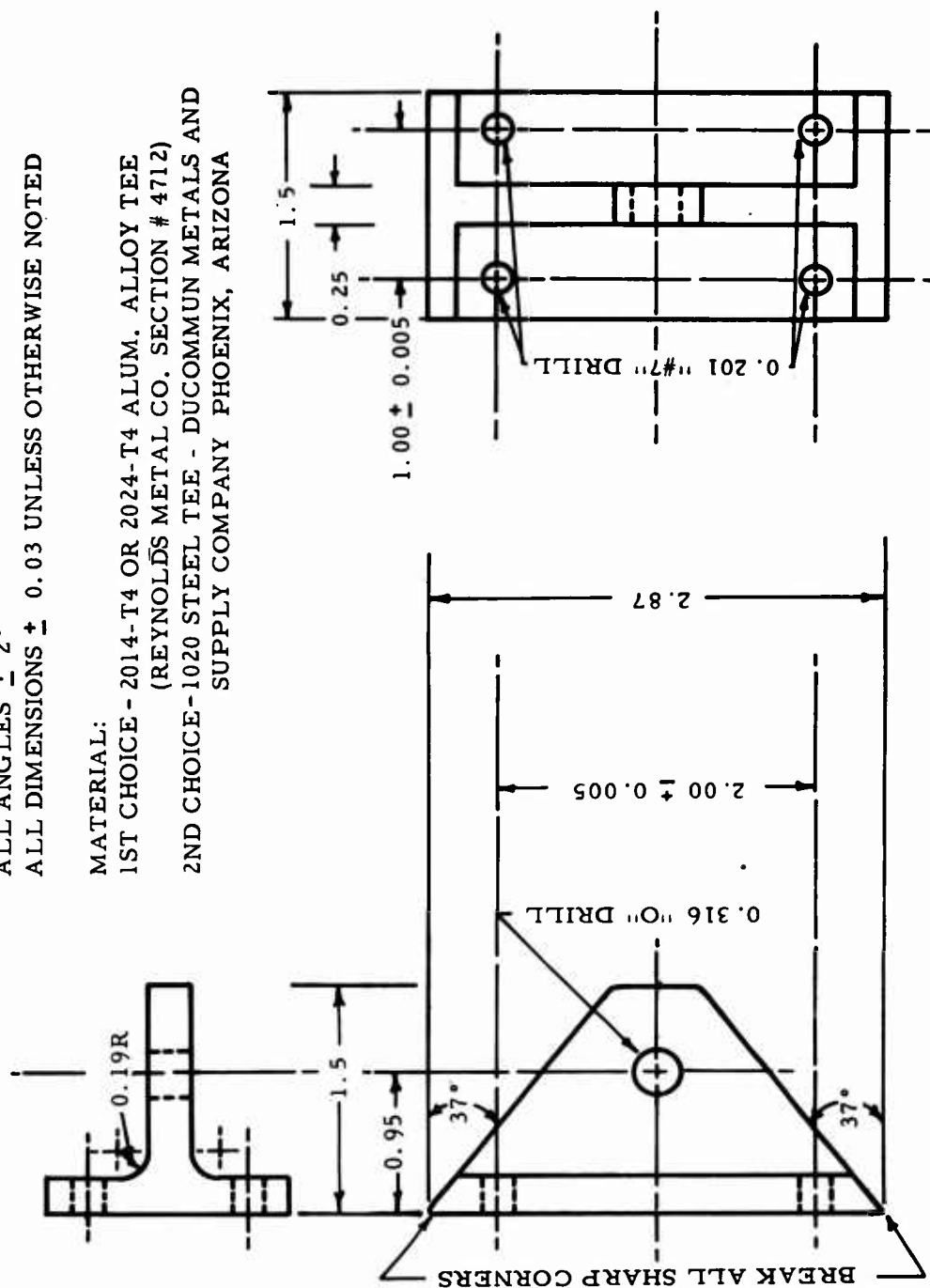


Figure 8. "Tee" Fitting HU-1-3.

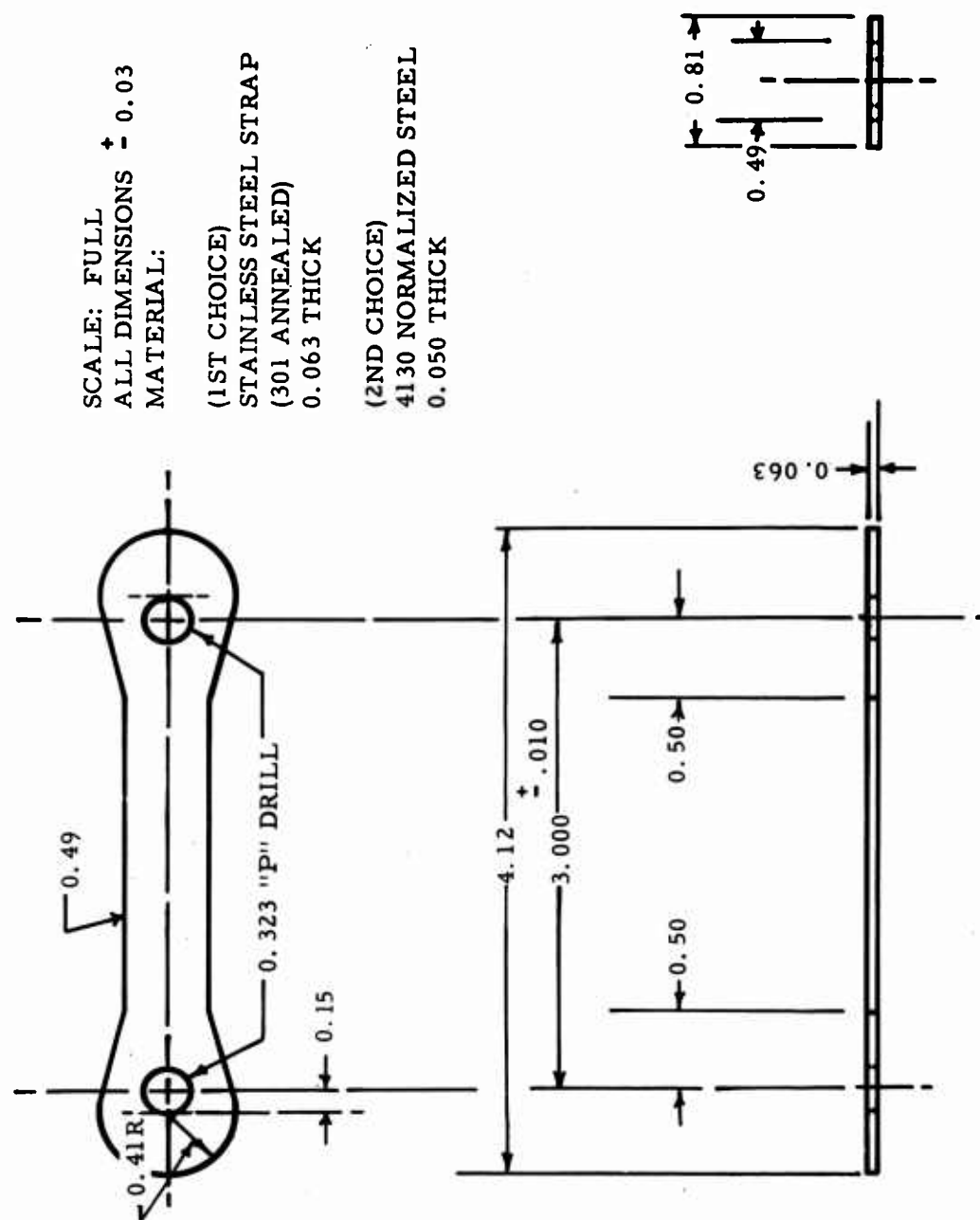


Figure 9. HU-1-1 Strap.

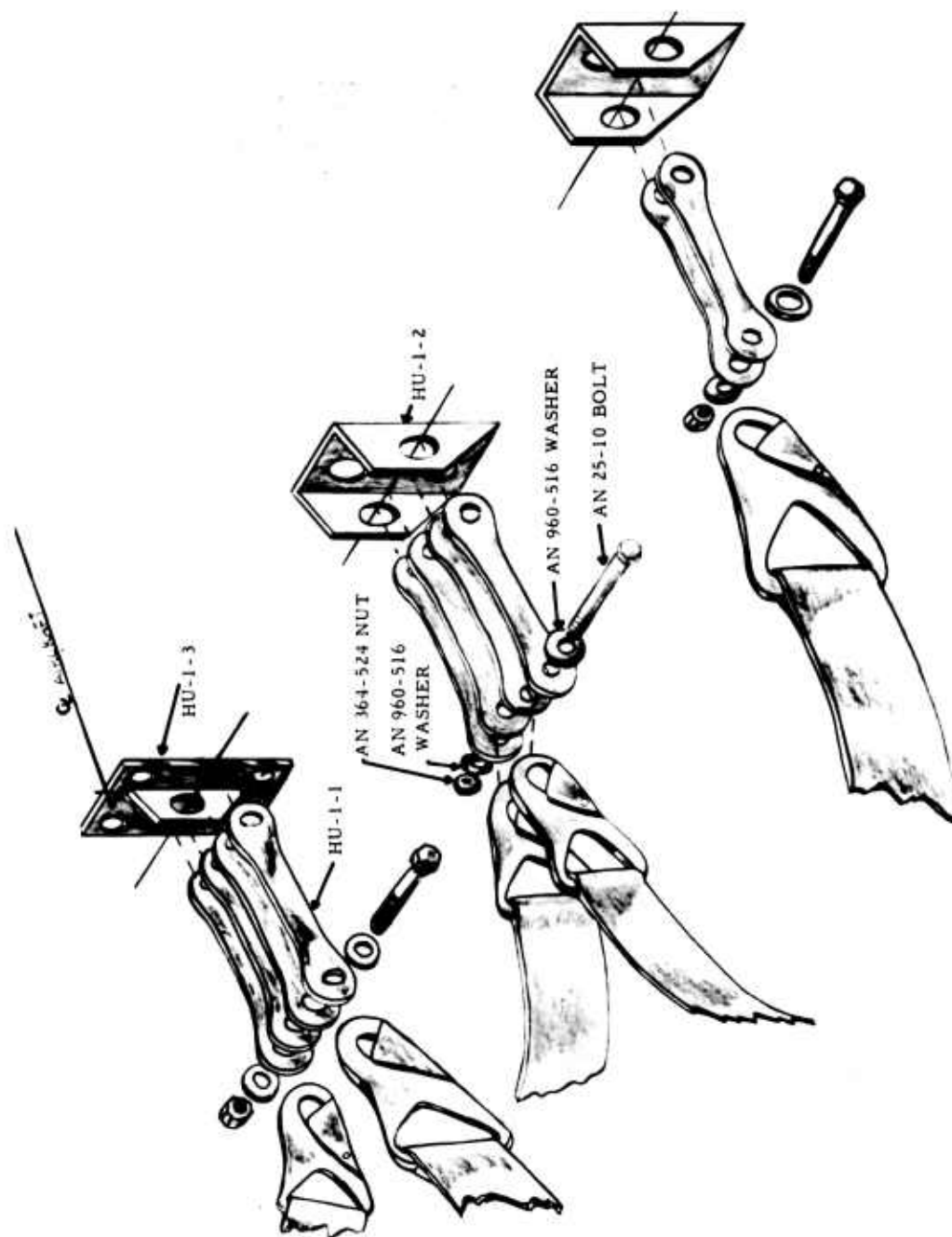


Figure 10. Installation Diagram.

INSTALLATION OF RETROFIT TIEDOWN FITTINGS (See Figure 10.)

1. Manufacture locally or obtain through normal supply channels the necessary fittings and straps (see Figures 7, 8, and 9).
2. Remove existing tiedown fittings and retain mounting bolts.
3. Install new "Channel" and "Tee" fittings, using mounting bolts retained from removed fittings and two washers AN 960-516 per bolt, one on each side of the fittings.
4. Mount HU-1-1 straps to HU-1-2 "Channel" brackets, using AN 5-15 bolts and AN 365-524 nuts.
5. Mount HU-1-1 straps to HU-1-3 "Tee" fitting, using one AN 5-10 bolt and one AN 365-524 bolt.
6. Insert one AN 25-10 bolt with two AN 960-516 washers (located on the outside of the straps) and secure with a nut AN 364-524.
7. Clip the seat belt clip around the AN 25-10 bolt between the straps.

COPY

APPENDIX I. CRASH TELEFAX

Telefax

WESTERN UNION

Telefax

L LLBO54 GOVT DL PD LOS ANGELES CALIF 31 1205 PPDT
DIR CORNELL AVN CRASH INJ RSCH, DO NOT FWD 1961 Aug 31
SKYHARBOR APT PHOENIX ARIZ
ACTION FOR DIR ARAVNSAFETYBE FT RUCKER ALA, CG
UCSUPMAINTCMD STL, CG USATHREE FT MCPHERSON GA, DIR
CORNELL AVN CRASH INJ RSCH SKY HARBOR APT PHOENIX
ARIZ, INFORMATION FOR CG EIGHTEEN-ZABNCORPS AND FT
BRAGG FT BRAGG NO. FROM AJCGC-F H-1044

1. THIS IS A SAFETY OF FLIGHT MSG.
2. REF MAJOR AIRCRAFT ACCIDENT INVOLVING HU-1A SN
59-1651 ON 17 AUG 61 DURING EXERCISE SWIFT STRIKE.
3. CREW CHIEF WAS SITTING IN LEFT PASSENGER SEAT WITH
SAFETY BELT FASTENED. INVESTIGATION REVEALED THAT
CREW CHIEFS LEFT SAFETY BELT CABLE ATTACHING
BRACKET (PN 04-070-961-1) FAILED DURING THE ACCIDENT
ALLOWING THE OCCUPANT TO FALL FREE WITHIN CARGO
COMPARTMENT. AIRCRAFT STRUCK GROUND IN A RIGHT
SKID LOW ATTITUDE WITH NEGLIGIBLE FORWARD
VELOCITY.
4. DURING MAINTENANCE ON HU-1A CREW CHIEF UNIN-
TENTIONALLY APPLIED LATERAL (SIDE) FORCE ON A
PASSENGER SAFETY BELT CAUSING THE CABLE ATTACH-
ING BRACKET TO BREAK IDENTICAL TO BRACKET IN
ABOVE ACCIDENT.
A CHECK WAS MADE ON TWO OTHER SAFETY BELTS AND
IT WAS FOUND THAT THE BRACKETS WOULD FAIL WHEN
A SIDE LOAD LESS THAN 200 NR WAS APPLIED.
5. UR BEING SUBMITTED.

CG 101ST ABNDIV AND FT CAMPBELL FT CAMPBELL KY
300020Z

AJCGC-F H-1044 1 2 HU-1A 59-1651 17 61 3 (PN 04-070-961-1)

This copy of a recent crash Telefax message explains how 200 pounds
force broke the seat-belt tiedown bracket in the passenger compart-
ment.

APPENDIX II. TOTAL COST TO RETROFIT ONE AIRCRAFT BY
PERMANENT SOLUTION METHOD

<u>Parts Required</u>	<u>Quantity</u>	<u>Cost Each</u>	<u>Cost Aircraft</u>
Steel Strap (HU-1-1)	16	\$.49	\$ 7.84
"Channel" Fitting (HU-1-2)	4	3.05	12.20
"Tee" Fitting (HU-1-3)	1	2.90	2.90
<u>Standard Hardware</u>			
AN 5-15 Bolt	4	.07	.28
AN 5-10 Bolt	1	.06	.06
AN 25-10 Bolt	8	.06	.48
AN 365-524 Nut	5	.05	.25
AN 364-524 Nut	8	.04	.32
AN 960-516 Flat Washer	40	.01	.40

Total Cost \$ 24.73

Notes:

1. Prices are based upon quotations from machine shops and vendors in the Phoenix, Arizona, area. Prices were based upon quantities of 500 each for the above items. Cost of fittings varied less than 10 percent between the 1st and 2nd choice material; therefore, an average cost was used.
2. Materials to be used.
 - (a) HU-1-1 strap

1st choice: 301 Annealed Stainless Steel, 0.063-inch thick.
2nd choice: 4130 normalized steel, 0.050-inch thick.
 - (b) HU-1-2 "Channel"

1st choice: 301 Annealed Stainless Steel, 0.125-inch thick.
2nd choice: 2014-T4 Extrusion per AND 10137-1309.

(c) HU-1-3 "Tee"

1st choice: 2014-T4 Extrusion per Reynolds Metal Co.
Section No. 3441 "Tee"

2nd choice: 1020 Mild steel "Tee" per Ducommun Metals,
& Supply Co.

APPENDIX III. FRACTURE TOUGHNESS OF METALS

The capability of a material to resist impact loads is called "Fracture Toughness", the measure of maximum energy absorption. The following quote* describes the difference between static and energy loads:

"Where the load is applied slowly there is a force to be resisted and the part needs stress resistance; where the load is applied suddenly there is energy to be absorbed and the part needs energy resistance, which may be the critical condition rather than the stress resistance. A material may serve well for one case and not for the other."

The ability of various materials to absorb energy loads can be measured by comparing the area enclosed by the stress-strain curves of each. Since the stress-strain relationship (as occurs up to the ultimate strength of a material) is not readily available, the following equations** can be used to approximate closely the area enclosed by the stress-strain curves:

For ductile material with a definite yield point:

$$\text{Fracture Toughness} = \frac{s_y + s_u}{2} \cdot e_u \cdot AL$$

For ductile material without a definite yield point:

$$\text{Fracture Toughness} = \frac{2}{3} s_u e_u \cdot AL$$

where,

s_u = ultimate tensile strength in psi

s_y = yield tensile strength in psi

e_u = ultimate strain in inches per inch

A = area of material cross section in sq. inch

L = length of material absorbing energy

* Draffin, J. O. and Collins, W. L., Statics and Strength of Materials, The Ronald Press Company, New York, 1950, p. 138.

** Seely, F. B., M. S., Resistance of Materials, John Wiley & Sons, Inc., New York, February 1949, p. 315.

These equations are used to calculate the fracture toughness of several materials, as shown in the tabulation on the following page.

The properties of 2014 and 2024 aluminum alloys are taken from pages 72, 73, and 125 of Reynolds Metal Company's "Aluminum Data Book" since the -T3 and -T4 tempers of both were not available in ANC-5, "Strength of Metal Aircraft Elements". All other material properties are taken from the ANC-5 Handbook.

The materials in the following table were all selected for their high-energy-absorption qualities. The elongation of the castings shown is much higher than that of other types, which are as low as 1.5 percent, but it can be seen that even the best castings are not as efficient as wrought materials for absorbing energy loads.

Note that materials with widely varying mechanical properties are capable of absorbing identical energy loads. For example, the 150 Ksi, 4130 steel, and the 75 Ksi stainless steel are nearly equal in energy absorption, but the annealed stainless steel would sustain an average load only half that of the 4130 steel during an impact loading. This fact is important when human tolerance is considered in a restraint system. For this reason, the annealed stainless steel was selected for the HU-1-1 belt straps since it would yield at 10G belt loads, whereas normalized 4130 steel would not yield until 20G was reached. The annealed straps would relieve the load in the lap belt at initial deceleration onset because of its lower yield to ultimate strength ratio.

The annealed 301 stainless steel is the best material of which we are aware for use in harness restraint components because of its very low yield strength to ultimate strength ratio of 0.4 combined with 50 percent elongation properties.

The cost of 301 stainless is three times that of normalized 4130 steel, but its elongation is three times as great and the cost of stainless is partially offset by the lack of any necessary finishing processes.

FRACTURE TOUGHNESS COMPARISON OF SEVERAL METALS

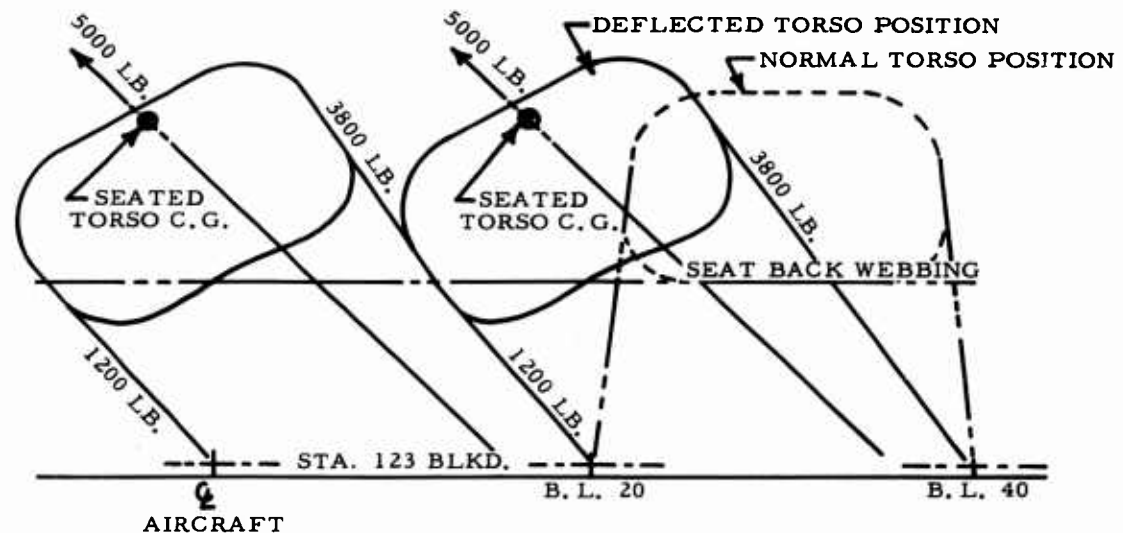
Material	Form	Temper	Tensile Strength		Elongation Per-cent	Toughness In.-lb.	Density Lb. per cu. in.	Toughness		Approx. Cost Dollars per lb.
			Ult. Ksi	Yield Ksi				Density	In.-lb. per lb.	
Al. Alloys:										
195	Sand casting	-T4	29*	13	6	1160	.102	11,400		0.90
200	Sand casting	-T4	42*	22	12	3360	.093	36,200		0.90
2014	Sheet	-T3	57	36	15	5700	.101	56,400		0.90
2014	Extrusion	-T4	50	30	12	4000	.101	39,600		1.20
2024	Sheet	-T3	64	42	15	6400	.100	64,000		0.95
2024	Extrusion	-T4	60	40	10	4000	.100	40,000		1.25
Steels:										
1025	All wrought forms	Normalized	55	36	22	10,000	.283	35,300		0.20
4130	All wrought forms	Normalized	90	70	17	13,600	.283	48,000		0.49
4130	All wrought forms	150,000	150	132	18	25,400	.283	89,800		0.50
301 Stainless	Sheet	Annealed	75	30	50	26,200	.286	91,700		1.45
301 Stainless	Sheet	1/4 Hard	125	75	25	25,000	.286	87,500		1.50
**This is the minimum guaranteed strength of a separately cast test bar. The mechanical properties of production castings may be as low as 75 percent of this value.										

*This is the minimum guaranteed strength of a separately cast test bar. The mechanical properties of production castings may be as low as 75 percent of this value.

APPENDIX IV. STRESS CALCULATIONS

STRESS CHECK OF HU-1 LAP BELT TIEDOWN FITTINGS

The three parts analyzed in this appendix are shown in Figure 10 of this report. It is assumed that the majority of helicopter accidents will exert crash forces within a 45-degree angle from the longitudinal axis of the aircraft; the most critical lap belt loading would be at 45 degrees because of the unequal loading as shown in the sketch below:



TOP VIEW

The human torso (as outlined by the pelvic extremities) would move approximately to the position shown. It is very difficult to determine the exact position of the belt with the applied load shown because of the unknown lateral resistance of the seat back, but the assumption is made that the lateral load would tear the seat back webbing and the belt would align itself as shown. The belt as shown has stretched a total of 10 inches, which is the average value determined from 2-inch-wide belt tests; tests have indicated that 3-inch-wide belts would deflect approximately 6 inches. The amount of deflection should not materially affect the distribution of belt loads.

With the previous assumptions, the load distribution would be in a ratio of 3 to 1 (3,800 pounds to 1,200 pounds). Future experimental tests should determine this ratio more accurately, but we believe this to be a good approximation.

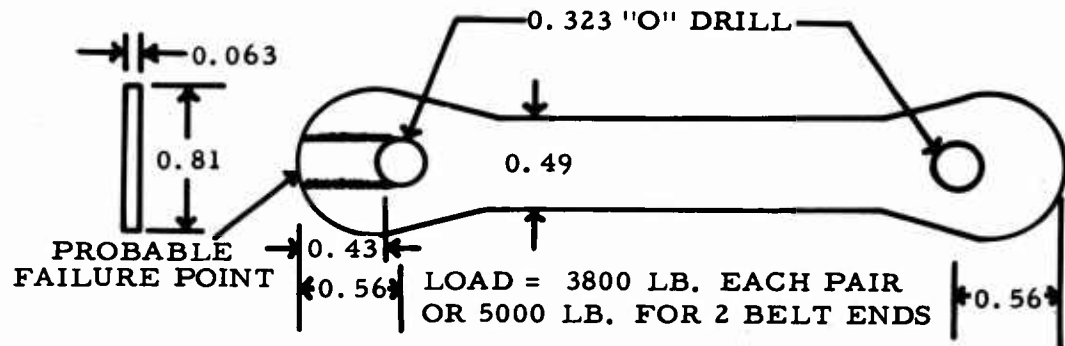
HU-1-1 STRAP

1st Choice Material: Annealed 301 Stainless Steel

F_{tu}	=	75,000
F_{su}	=	40,000
F_{bru}	=	150,000

2nd Choice Material: 4130 Normalized Steel

F_{tu}	=	90,000	} .050 thick
F_{su}	=	70,000	
F_{bru}	=	140,000	



The following stress check is based on Annealed 301 Steel:

$$S_s = \frac{1900}{.43(.063)(2)} = 35,000 \text{ psi} \quad \text{M. S.} = \frac{40,000}{35,000} - 1 = .14$$

$$S_t = \frac{1900}{.063(.50)} = 60,200 \text{ psi} \quad \text{M. S.} = \frac{75,000}{60,200} - 1 = .24$$

$$S_{br} = \frac{1900}{.063(.25)} = 124,000 \text{ psi} \quad \text{M. S.} = \frac{150,000}{124,000} - 1 = .21$$

The bending loads are ignored because of the use of thin ductile material.

The normalized 4130 steel has not been analyzed, but it can be used with a thickness of .050 inch since its added strength offsets the decreased thickness.

HU-1-2 CHANNEL FITTING

1st Choice Material: Annealed 301 Stainless
Steel, 0.125 thick

$$F_{tu} = 75,000$$

$$F_{su} = 40,000$$

$$F_{bru} = 150,000$$

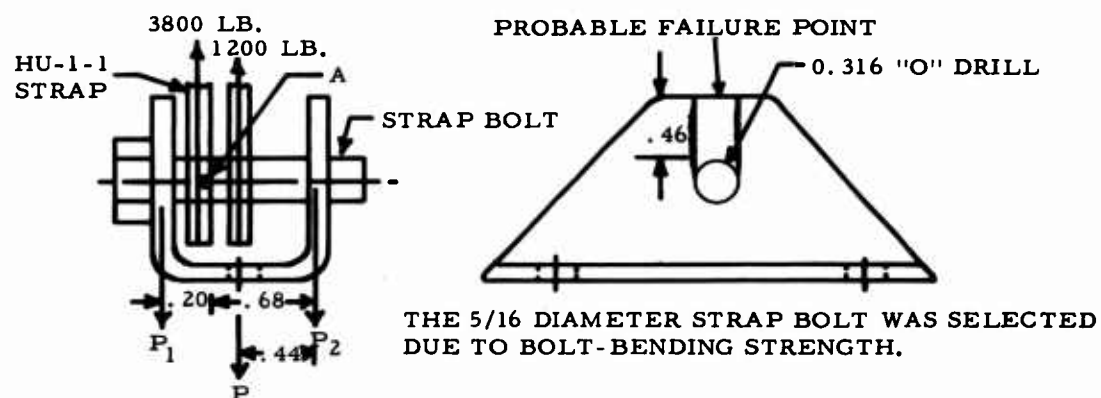
2nd Choice Material: 2014-T4 Extrusion, 0.156
thick

$$F_{tu} = 60,000$$

$$F_{su} = 35,000$$

$$F_{bru} = 90,000$$

(AND 10137-1309)



The following stress check is based on the use of annealed 301 steel.

$$P_1 + P_2 = 5,000 \text{ lbs.}$$

$$[\Sigma M_a] \text{ (c. g. of total load for off-center condition)}$$

$$.20 P_1 = .68 P_2$$

$$P_2 = 1140 \text{ lbs. } P_1 = 3860 \text{ lbs.}$$

$$S_s = \frac{3860 \text{ lbs.}}{.125(2) (.46)} = 33,400$$

$$M. S. = \frac{40,000}{33,400} - 1 = .20$$

S_t is O. K. by inspection

$$S_{br} = \frac{3860 \text{ lbs.}}{.125 (.31)} = 99,500 \quad \text{M. S.} = \frac{150,000}{99,500} - 1 = \underline{.50}$$

Check 1/4-diameter tiedown bolts.

$$P_1 (.20 + .68) = P(.44)$$

$$P = 7720 \text{ lbs.} + 2 \text{ bolts} = 3,860 \text{ each} \quad \text{M. S.} = \frac{4080}{3860} - 1 = \underline{.05}$$

Shear stress around tiedown bolt heads:

$$S_s = \frac{3860 \text{ lbs.}}{.125 \pi (.45) \text{ bolt head diameter}} = 21,800 \text{ psi}$$

$$\text{M. S.} = \frac{40,000}{21,800} - 1 = \underline{.83}$$

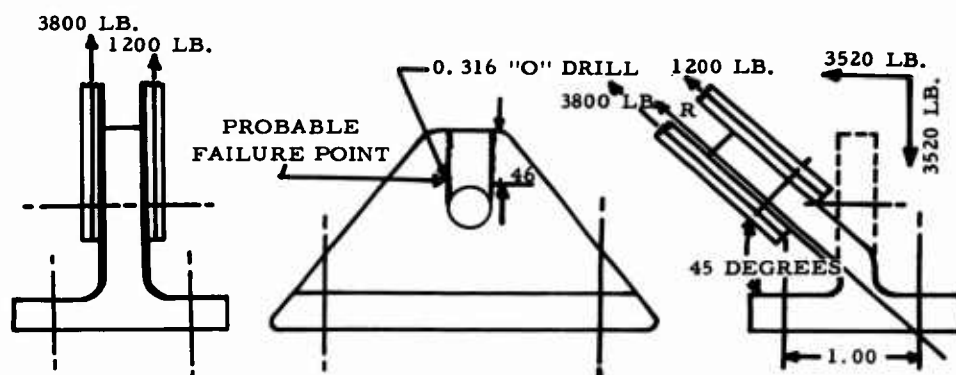
Lateral shear loads are not considered in the above analysis since the ductile material of the channel flanges would yield in the direction of the lateral load.

The 2014-T4 (AND 10137-1309) Extrusion has not been analyzed since the .156-inch thickness selected offsets the decrease in strength properties.

HU-1-3 "TEE" FITTING

1st Choice Material:	2014-T4 "Tee" Extrusion,	F_{tu}	=	60,000
	1/4 thick	F_{su}	=	35,000
		F_{bru}	=	90,000

2nd Choice Material:	1020 Mild Steel, Ducommun	F_{tu}	=	55,000
	Metals & Supply Co.,	F_{su}	=	36,000
	Phoenix, Arizona, Metals	F_{bru}	=	110,000
	Stock List, p. 244, 1/4			
	thick			



STRESS CHECK MADE ON 1020 MILD STEEL:

Check of 3/16-Inch-Diameter Tiedown Bolts:

As can be seen in the sketch above, if a load were applied at 45 degrees, as shown, the web of the "Tee", when reaching its yield strength, would start bending and would direct a major part of the load through only two of the tiedown bolts:

$$3/16\text{-inch-diameter tiedown bolt} \quad \text{M. S.} \quad \frac{2210 \text{ lbs.} \times 2 \text{ bolts}}{3520 \text{ lbs.}} - 1 = \underline{0.25}$$

The shear load is not checked since it occurs at a point away from the maximum tensile stress in the bolt threads. The 5/16-inch-diameter hole is specified to agree with the HU-1-2 channel so that all straps will be identical.

$$S_s = \frac{5000 \text{ lbs.}}{.25 (.46) (2)} = 21,700 \text{ psi} \quad \text{M. S.} = \frac{36,000}{21,700} - 1 = \underline{.66}$$

$$S_{br} = \frac{5000 \text{ lbs.}}{(.25) (.25)} = 80,000 \text{ psi} \quad \text{M. S.} = \frac{110,000}{80,000} - 1 = \underline{.38}$$

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36 pp. - illus. - (Contract DA-44-
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